1 454 128

PATENT SPECIFICATION

(11) 1 454 128

(21) Application No. 25634/74 (22) Filed 10 June 1974
(21) Application No. 25635/74 (22) Filed 10 June 1974
(21) Application No. 9572/75 (22) Filed 7 March 1975
(23) Complete Specification filed 22 May 1975
(44) Complete Specification published 27 Oct. 1976
(51) INT CL² F28D 1/06 F17C 7/02
(52) Index at acceptance
F4P 12A1 12C1B 12C2C1
B7H A5
B7L 12J

(72) Inventors JOHN CHRISTOPHER LEAHY and JOHN DUNBAR KIBBLE

(54) A PNEUMATIC DRIVE USING REVAPORISED LIQUEFIED-GAS

(71) We, COAL INDUSTRY (PATENTS) LIMITED, a company organised in accordance with the laws of Great Britain of Hobart House, Grosvenor Place, London, S.W.1. 7AE England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to revaporised liquefied gas actuated drives and in particular, although not exclusively, to revaporised liquefied-gas actuated drives for vehicles.

It is known for a revaporised liquefied-gas drive to comprise an insulated vessel containing liquefied-gas and for liquid to be pumped out of the vessel to a liquid pressure intensifier powered by pressurized gas derived from the pressurised liquid leaving the intensifier. One such prior known revaporised liquefied-gas drive is disclosed in a prior published United States of America Patent Specification No. 3,451,342.

The revaporised liquefied-gas drive disclosed in the above numbered Patent Specification suffered from the disadvantage that the drive was not self-starting. The gas required to actuate the intensifier was derived from pressurised liquefied-gas leaving the intensifier so that it follows that an external prime mover was required to start and actuate the intensifier until a sufficient gas supply could be obtained to actuate the intensifier.

An object of the present invention is to provide a revaporised liquefied-gas drive which tends to overcome the above mentioned disadvantage.

According to the present invention a revaporised liquefied-gas drive comprises a sealed vessel for liquefied-gas, the vessel having valve means for maintaining the pressure in the vessel at a preselected level, passage means for feeding liquefied-gas from the vessel under the action of the preselected pressure level existing in the vessel to a liquid pressure intensifier and for feeding gas to actuate the liquid pressure intensifier which thereby acts on the liquefied-gas to increase its pressure above the preselected level, the gas being derived from the liquefied-gas at the preselected pressure level, and a revaporiser device for converting liquefied-gas discharged from the intensifier to a gaseous state.

Preferably, the drive comprises a motor arranged to receive gas discharged from the revaporiser device.

Advantageously, a heater device for converting liquefied-gas to a gaseous state is arranged to receive liquefied-gas at the preselected pressure level and to feed the derived gas to the liquid pressure intensifier.

Conveniently, the said passage means includes a passage for feeding gas contained within the vessel directly to actuate the liquid pressure intensifier.

Advantageously, the passage means includes separate passages for feeding liquid to the intensifier and to the said heater device, respectively.

Preferably, an exhaust passage from the motor feeds exhaust gas to actuate the intensifier.

The present invention also provides a liquefied-gas drive as defined above in combination with a vehicle.

By way of example only, three embodiments of the present invention will be described with reference to the accompanying drawings, in which:—

Figure 1 is a circuit diagram of a revaporised liquefied-gas drive constructed in accordance with a first embodiment of the present invention.

Figure 2 is a diagrammatic side view of a vehicle including the drive of Figure 1;

Figure 3 is a circuit diagram of a portion of a revaporised liquefied-gas drive constructed in accordance with a second embodiment of the present invention; and

Figure 4 is a circuit diagram of a revaporised liquefied-gas drive constructed in accordance with a third embodiment of the present invention.

Referring to Figure 1 of the drawings, liquefied-gas, for example, liquefied-nitrogen, is contained in an insulated sealed vessel 1 in which the pressure is maintained at a preselected level, for example six atmospheres, by pressure relief valves (not shown). The maintained preselected pressure level is sufficient to force liquefied-nitrogen along passage means comprising a branched pipe 2 leading via a self-sealing connector 3 to a liquid pressure intensifier 4 and having a branch 6 leading to a coiled passage 7 of a heater device 8 for converting liquefied-nitrogen to a gaseous state. Liquid in the device 8 at the preselected pressure absorbs heat from the atmosphere, boils and passes as gas from the device 8 to a receiver 10 having two self-sealing connectors 12 and 14. A self-sealing connector permits easy connection or disconnection between the receiver and a pipe and also ensures that when disconnected the pressurised receiver is closed against leakage. In the drawing, connector 12 is shown unattached or disconnected and provides a power-take-off point for attachment to the supply pipe or hose of pneumatically driven equipment (not shown).

Connector 14 is shown connected to a feed pipe 16 of the liquid pressure intensifier 4 and supplies gaseous nitrogen at a pressure sufficient to actuate the intensifier to increase the pressure of the liquefied-nitrogen received via pipe 18 attached to connector 3. The gas used to actuate the intensifier is subsequently exhausted to atmosphere via pipe 19.

Pressurised liquefied-nitrogen at a pressure, for example, of two hundred atmospheres, is fed along pipe 20 from the intensifier 4 to a first coiled passage 21 of a revaporiser device for converting to a gaseous state the high pressure liquefied-nitrogen pressurised above the preselected level. The revaporiser device includes two stages 22 and 23 and is arranged to feed gas to actuate a pneumatic motor 24. Liquefied-nitrogen entering the coiled passage 21 at above the preselected pressure, absorbs heat from the atmosphere, boils and passes as gas from the first stage 22 of the revaporiser device and along pipe 26 to a high-pressure cylinder 28 of the motor 24. Gas exhausted from the cylinder 28 is passed along a coiled passage 30 of the second stage 23 of the revaporiser device and is re-heated by absorbing heat from the atmosphere and fed to a low-pressure cylinder 32 of the motor 24 before being exhausted via pipe 33 to atmosphere.

It will be noted that the components 1, 8 and 10 are formed as a unit assembly 35 with the self-sealing connectors 3, 12 and 14, allowing the unit assembly to be removed from the remainder of the drive. This facilitates easy removal of the pneumatic power supply which is thereby mobile and which may be replaced by a freshly charged unit assembly or may be conveyed to provide a supply of liquefied or gaseous nitrogen at the preselected pressure at a location remote from the remainder of drive.

A typical railmounted, man-riding vehicle including the above described drive is shown in Figure 2 of the drawings. The unit assembly 35 is releasably mounted on a chassis 40 by quick-release clasps 41. Figure 2 indicates the positions of the heater device 8 and of the revaporiser device 22, 23 and shows the motor 24 drivably connected via gearing 47 to the vehicle's pair of drive wheels 44. A driver 45 and passenger (not shown) set in a seat 46 and are shielded from the boiler devices by a screen 48. A drive control panel 50 is provided. From Figure 2 it can be seen that the receiver 10 is constructed as a hollow framework arranged around the remainder of the unit assembly 35.

Figure 3 shows a removable unit assembly 51 of a second embodiment of the present invention. The unit assembly 51 includes passage means consisting of a passage 54 for feeding gaseous nitrogen from sealed vessel 55 directly to a receiver 56 and thus provides gaseous nitrogen to actuate the liquid pressure intensifier (not shown in Figure 3). The passage means also comprises a second passage 2 which feeds liquefied-nitrogen from the vessel 55 via self-sealing connector 3 to the intensifier.

With the second described embodiment no heater device is provided for converting liquefied-gas at the preselected pressure to gas. The receiver 56 is charged directly from the vessel 55.

In Figure 3 the same reference numerals are used for similar items to those described with reference to the first embodiment in Figure 1.

Referring now to Figure 4 which is a circuit diagram for a third embodiment of the present invention, cryogenic liquid, for example liquefied-nitrogen, is stored in an insulated closed vessel 101, equipped with relief valve 102 to maintain the pressure in the vessel at or just below a preselected

level. The liquefied-nitrogen flows under the action of the vapour pressure in the vessel through an intake check valve 103, into a high-pressure small bore end of a liquid pressure intensifier 104, and then, at a pressure above the preselected level through a second delivery check valve 105, into a revaporiser device 106. The vaporised and superheated gas is then passed to an expansion motor 107 and exhausted to atmosphere through a restriction or back-pressure valve 108. The back pressure is fed back through a gas feed pipe 100 and a re-heater device 113 to a large-bore low-pfessure end of the intensifier 104. A regulator 109 is used to control the maximum available feed pressure fed to the intensifier 104. A small-bore feed pipe 110 carries gaseous nitrogen directly from the gas space in the storage vessel 101 to the low pressure actuating side of the intensifier 104, through a non-return valve 111. Gas for start-up of the intensifier is fed through pipe 110 and valve 111 to the intensifier. When the motor 107 has started, the exhausted gas from the engine supplies sufficient residual energy to actuate the intensifier. The non-return valve 111 effectively protects the vessel from the gas feed along pipe 100. The heater device 112 may be connected to the starting feed line to facilitate pressurisation of the storage space and provide rapid starting of the pumping action. The heater device 112 is fed with liquefied-nitrogen from the vessel 101 by the action of gravity.

In different embodiments of the invention the motor may have more than two stages.

WHAT WE CLAIM IS:—

1. A revaporised liquefied-gas drive comprising a sealed vessel for liquefied-gas, the vessel having valve means for maintaining the pressure in the vessel at a preselected level, passage means for feeding liquefied-gas from the vessel under the action of the preselected pressure level existing in the vessel to a liquid pressure intensifier and for feeding gas to actuate the liquid pressure intensifier which thereby acts on the liquefied-gas to increase its pressure above the preselected level, the gas being derived from the liquefied-gas at the preselected pressure level, and a revaporiser device for converting liquefied-gas discharged from the intensifier to a gaseous state.

2. A drive as claimed in claim 1, comprising a motor arranged to receive gas discharged from the revaporiser device.

3. A drive as claimed in claim 1 or 2, in which a heater device for converting liquefied-gas to a gaseous state is arranged to receive liquefied-gas at the preselected pressure level and to feed the derived gas to the liquid pressure intensifier.

4. A drive as claimed in claim 1, 2 or 3, in which the said passage means includes a passage for feeding gas contained within the vessel directly to actuate the liquid pressure intensifier.

5. A drive as claimed in claim 3 or claim 4 when dependent on claim 3, in which the passage means includes separate passages for feeding liquid to the intensifier and to the said heater device, respectively.

6. A drive as claimed in any one of the preceding claims 2 to 5, in which an exhaust passage from the motor feeds exhaust gas to actuate the intensifier.

7. A drive as claimed in any one of the preceding claims, in combination with a vehicle.

8. A revaporised liquefied-gas drive, substantially as described with reference to Figures 1 and 2, or Figure 3, or Figure 4 of the accompanying drawings.

9. A vehicle including a drive substantially as described with reference to Figures 1 and 2, or Figure 3, or Figure 4 of the accompanying drawings.

For the Applicants,
J. I. WOOD.
Chartered Patent Agent.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1976.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1454128 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

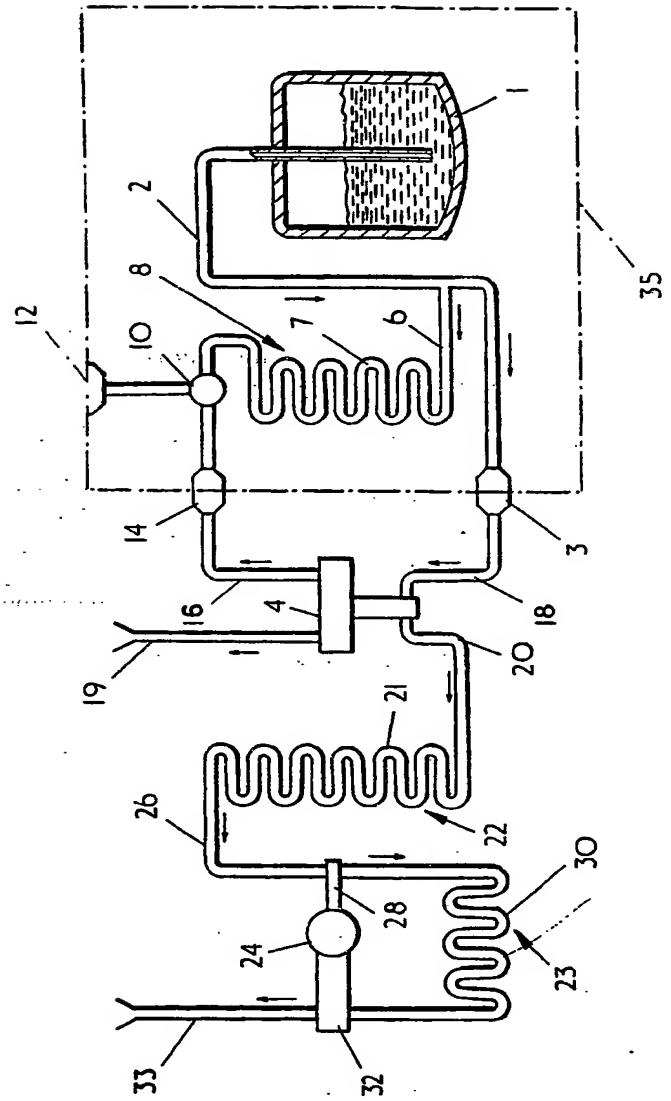

FIG. 1.

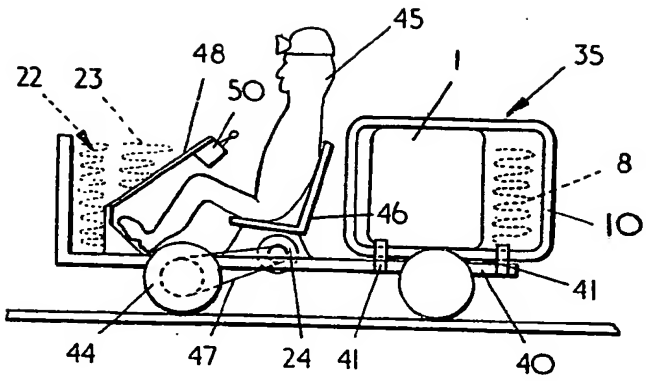

FIG. 2.

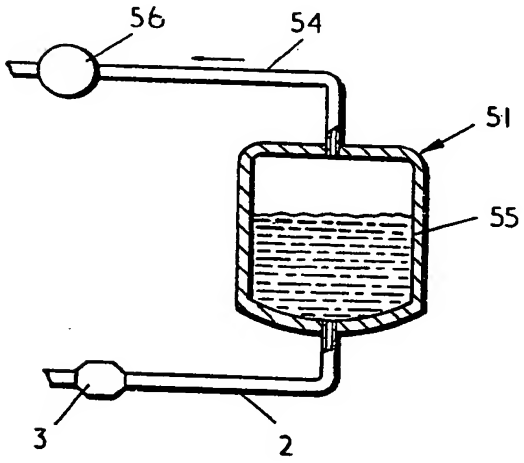

FIG. 3.

1454128 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

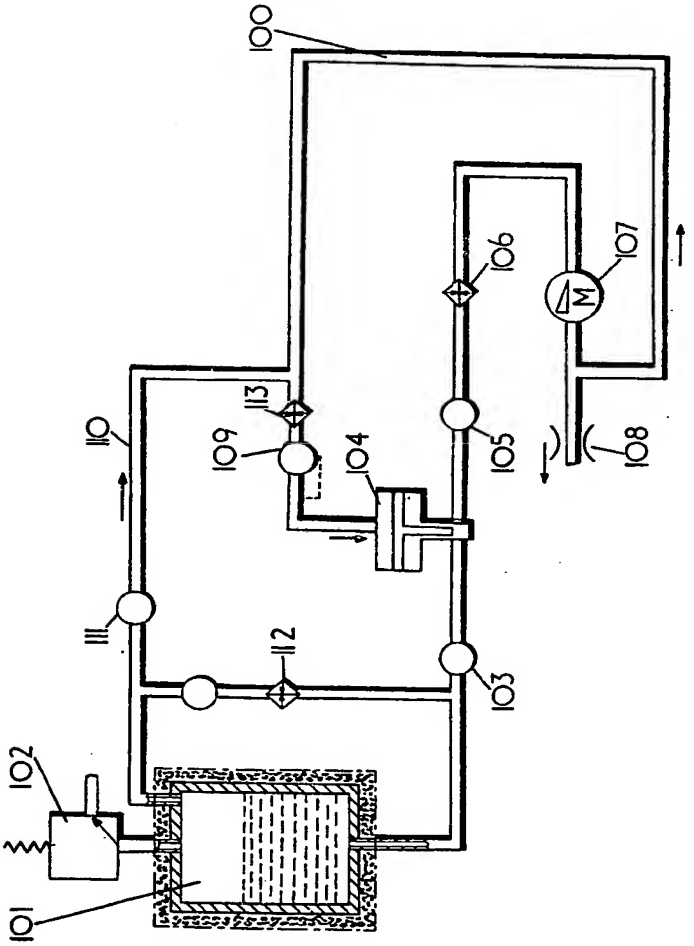

FIGURE 4.